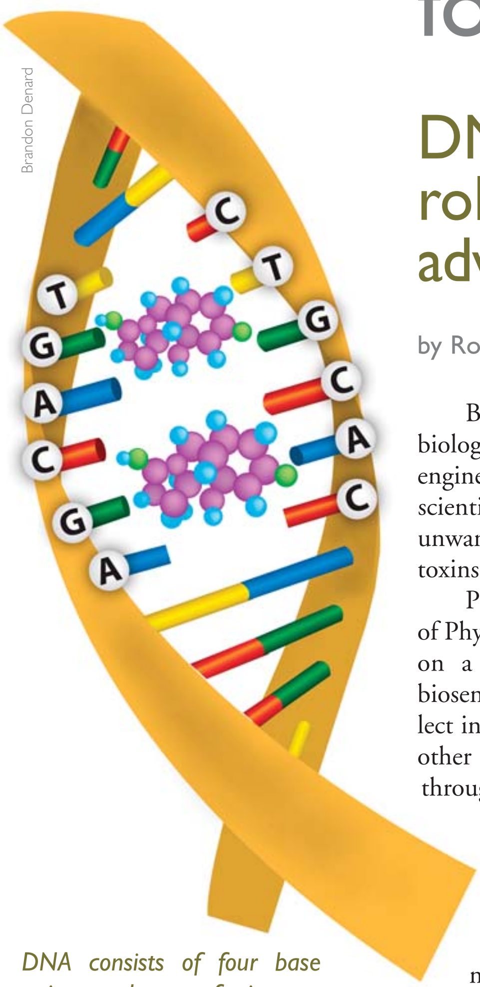
Flipping the molecular switch for food safety

DNA plays key role in developing advanced biosensors

by Robert Fieldhouse



Brandon Denard

DNA consists of four base pairs, made up of nitrogen-rich molecules which code for specific traits. Normally, the bases adenine (A) and thymine (T) pair up, while cytosine (C) and guanine (G) attract one another. In this simplified illustration of artificially created DNA, three pairs of bases opposite one another do not match up properly, forming a pocket which then binds a target molecule, creating an electric charge.

Biosensors — tiny devices that can detect biological molecules — built with specially engineered DNA strands may one day advance scientists' ability to detect a wide variety of unwanted components, including metabolites, toxins and food contaminants.

Prof. John Bechhoefer of the Department of Physics at Simon Fraser University is working on a collaborative project to develop new biosensors that use biological materials to collect information — often about the presence of other biological materials — and transmit it through electrical signals.

These new biosensors will be based on DNA aptamers (short DNA strands that form pockets to bind target molecules) that act like electrical switches, activated by a particular molecule's presence.

Normal switches are gaps in wires that disrupt the flow of an electrical transmission, but biosensor electrical switches are shaped like pockets. Whether or not they conduct electricity depends on the pocket's conformation.

"We're developing DNA pockets with specific angles that will trap specific target molecules," says Bechhoefer. "As the target binds, it will restore the electrical conductivity in the pocket, acting as a switch."

Biophysicists have previously shown that DNA conducts electricity. But unlike traditional conductors such as copper, DNA's conductivity changes depending on what it's bound to and what surrounds it.

Bechhoefer is using this feature to his advantage. The pockets he envisions have a particular shape and size that depend on the DNA strand's length and composition. And they'll conduct electricity only when a target molecule binds and flips the DNA switch.

But this switch isn't very useful if it's just DNA in solution, he says, because such switches aren't usually part of physiologically important electrical circuits. So he's using the DNA as if it were a wire. By surrounding DNA with a surface of insulating molecules, he hopes to conduct electricity between two gold particles (introduced by researchers in test situations) connected by DNA.

Bechhoefer anticipates certain advantages to using DNA sensors. Besides being highly sensitive and accurate, they're economical because there's no need for expensive cameras to observe them and no risk of molecules losing their fluorescence. They're also desirable because there are no radioactive byproducts to worry about, as is the case with some sensors.

He expects he'll soon have DNA strands with switches that are always turned on and ones that are always turned off, giving valuable baseline information for observing DNA conductivity.

Simon Fraser University researchers on this project include Prof. Dipankar Sen, Department of Molecular Biology and Biochemistry/Chemistry; Prof. Hogan Yu and graduate student Marcus Kuikka, Department of Chemistry; and Drs. Connie Roth and Yuekan Jiao and graduate student Shun Lu, Department of Physics. Other researchers are Prof. Nicholas Low, Department of Applied Microbiology and Food Science at the University of Saskatchewan; Prof. Tito Scaiano, Department of Chemistry at the University of Ottawa; and Prof. Peter Williams and undergraduate student Stefan Murphy, Department of Physics at Acadia University.

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